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RESEARCH ON THE TRANSPORTATION OF SOLIDS BY PIPELINE IN BRITAIN

by

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R.P. Charbonnier*

INTRODUCTION

During a field trip in Europe in June and July, 1962, inquiries were made to assess the importance of the facilities and activities of the few organizations engaged in research on the transportation of solids by pipelines.

It appears that, outside of the United States and Canada, most of this type of research has been conducted in Great Britain, France, and communist countries (mainly the U.S.S.R.)

From June 25th to 30th, 1962, the author was in London, U.K., to attend the Fourth Congress of the Federation of European Petroleum Equipment Manufacturers, and to visit the Chemical and Petroleum Engineering Exhibition of the Third Congress of the European Federation of Chemical Engineering. This opportunity was taken to make numerous inquiries from various companies and organizations, represented at the Exhibition and likely to have an interest in the transportation of solids by pipeline. An abundant documentation was collected and contacts were established with a number of organizations, which may be of assistance to us in the future.

NATIONAL COAL BOARD, MINISTRY OF POWER AND BRITISH HYDROMECHANICS RESEARCH ASSOCIATION

It was confirmed that most of the research on the pipelining of solids, in Great Britain, had been carried out by the National Coal Board (NCB) and more recently by the Central Electricity Generating Board (CEGB). Therefore, a visit was made to the Production Department of the NCB, which has been in charge of studies of hydraulic

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mining and transport of coal (Messrs. F.C. Taylor, Viccars, S. Weinberg, Alan Wright, Thomas, and Smith).

Extensive studies have been carried out, especially between 1953 and 1960, including large scale tests at the collieries of Markham and Woodend. Several papers were published, notably "Hydraulic transport of solid material in pipes" by R.C. Worster and D.F. Denny (Institution of Mechanical Engineers, Proceedings, 1955, V. 169, No. 32, pp. 563-86). This paper by BHRA research officers described the system design (with particular reference to coal handling plant), methods of pumping, characteristics of high pressure systems, rotary and reciprocating feeders, degradation of coal in transport, and plant maintenance.

Another paper of special interest was "Hydraulic transportation of solids" (Colliery Eng., V. 32, No. 375, May 1955, pp. 185-90; and No. 380, Oct. 1955, pp. 425-7), where experiments in hydraulic transportation of coal at Woodend Colliery were described.

In 1960, the NCB suspended all studies on the hydraulic mining and transportation of coal, probably because of changes in the economic situation of the coal industry rather than for technical reasons.

Four internal reports, of great value but not published, were obtained by the author from the NCB. The first report is entitled "Hydraulic Transport of Coal, Lock Hopper Loaders at Markham Colliery" by D.E. Elliott and T. Sparkes (Ministry of Power, Chief, Scientist Division, Sc. 302/5, Sc. 302/7 CSD 165, Sept. 1959). The other three reports constitute detailed summaries of the three main projects undertaken by the NCB in this field of research. They are: (1) Re. File No. P. 17458 "Hydraulic transport of coal at Markham Colliery" (NCB, Production Department, September 1961); (2) Re. File No. P. 17443 "Hydraulic transport of coal at Woodend colliery" (NCB, Production Dept., Sept. 1961); (3) Re. File No. P. 17442 "Exploratory triais in hydraulic mining at Trelewis drift mine" (NCB, Production Dept., Sept. 1961).

It may be of interest to note that, between 1913 and 1924, an 8" diameter pipeline pumping 25 tons/hour of coal on 660 yards was operated successfully at Hammersmith, G.B. In 1945, G.G. Bell proposed a coal pipeline transporting 2.5 million tons/year from the Midlands to London. The economics of this project were studied by the Fuel Research Station, and about 1951 the NCB instigated small scale laboratory work at the British Hydromechanics Research Association (BHRA).

MARKHAM TESTS

Later an ambitious full scale project was started by the NCB, at the Markham colliery of the No. 1 East Midland Area, with the project of pumping coal over a thousand feet to a washery. There the Ministry of Power tested a vertical lock hopper type of loader, which was then thought to offer the best promise for high pressure pumping of large coal from deep mines or over long horizontal distances. This vertical loader reached a satisfactory state of development, although its height (29 ft to the feed chute) presented costly problems. Trials were therefore carried out on a horizontal loader, which soon operated quite successfully, thus leading the NCB to build a three-cylinder horizontal loader at Bretby for use in a full scale underground hydraulic transport system at 150 psi. The tests showed that centrifugal pumps can deliver heads up to about 100 ft and can transmit large lumps of coal. Although these pumps were found superior for short distance transport, the complication of running several pumps in series to provide high heads was then considered prohibitive for their use in long distance transport or in pumping from deep mines. Reciprocating pumps were considered to be suitable to give high pressures with fine coal up to about 1/8". Larger sizes would cause valve problems. Four methods were tested at Markham: A) Vertical Lock Hopper Feeder, B) BHRA Feeder, C) Horizontal Lock Hopper Feeder, D) Gwynnes Solids Handling Pump.

A). Vertical Lock Hopper Feeder

The vertical lock hopper feeder was designed in 1954 for the Ministry of Power by B.V.C. (Construction) Ltd., in conjunction with Gwynne Pumps Ltd. It was rated at 200 tons/hour, and consisted essentially of a cylindrical vessel 8 ft in diameter, divided across a diameter to form two separate lock hoppers, alternately feeding into a common compartment below. The original design incorporated twin screws to control the feed into the pipeline, with nozzles to create an ejector effect. These screws were eventually removed following repeated blockages. The main difficulties were presented by the operation of the flap valves (later replaced by radial valves), agglomeration of fine coal and water over the top gates, high pressure fluctuations, inadequate sealing of valves. These defects limited the throughput to a maximum of 120 tons/hr, further restricted for safety to 60 tons/hr in regular operations. It was felt that a coal feed rate of 150 tons/hr might be possible by converting the hydraulic operating mechanism to pneumatics, and also by fitting a separate pump for the depressurizing and pressurizing operations. In any future design, it would be desirable to use three lock hoppers instead of two to improve the time cycle, and to obtain more uniform flow and pressure in the pipeline.

B) British Hydromechanics Research Association Reciprocating Feeder

The BHRA reciprocating feeder was primarily designed for high-pressure duty, with a capacity of 60 tons/ hr of minus 1 1/ 2 inch coal at 400 psi. In fact the minus 2 1/ 2 inch coal at Markham was largely fines, which were easily handled by the BHRA feeder. The unit consisted of a coal and water hopper, feeding directly (in turn) to three double-acting horizontal plungers in parallel lines. Each plunger contained two 8 x 4 inch pockets, open at the top and closed at the lower end by a fine mesh screen, capable of retaining the coal but allowing water to pass into a suction pump, during the period when the cycle placed the pocket under the hopper opening.

In the next stroke of the plunger, the pocket would be moved to a position under the outlet connected to the solids pipeline, and then the coal would be entrained by high pressure water pumped through an inlet under the screen. Severe water hammer persisted during the early trials. This difficulty was reduced by decreasing the feeder speed from 162 to 114 rpm, thus reducing coal throughput. On the delivery side, water hammer commenced at about 700 gal/ min, reaching severe intensity at 900 gal/ min. These phenomena seemed to be caused by resonance.

The maximum throughput obtained was only about 20 tons/ hr. It could not be increased because of the high percentage of fines in the coal supply with the resultant blocking in the hopper. Water hammer had not been encountered in the BHRA laboratory tests, which were conducted under 360 gal/ min. Considerable modifications of the BHRA design, seemed required to obtain higher outputs.

C) Horizontal Lock Hopper Feeder (British patent No. 9554/ 59)

This feeder was designed by the Ministry of Power, installed and tested by the NCB at Markham. The system comprised a storage bunker, which discharged coal into a mixing tank, connected with the suction side of a 6" Vacseal solids handling pump. This pump charged a 180 ft horizontal loop of 8 inch diameter pipe, connected with the main pipeline and, through valves, with high pressure water, and also with the mixing tank. The plug type valves were operated by hydraulic cylinders actuated by cam-controlled selector valves. Two or more loops would have been required to give a uniform discharge. While the loop was filled by the Vacseal pump with coal and water, the high water pressure was exerted on the pipeline beyond the loop through a by-pass. Later in the cycle, when the loop was full of the coal mixture, the high water pressure was diverted to the loop to sweep the mixture into the pipeline. The cycle of valve operations took one

minute but it could be increased with a larger loop. Main difficulties were due to water hammer phenomena, which were reduced by changing the pneumatic operation of the valves to a hydraulic control. The design capacity of 60 tons/ hr was achieved with only minor blockages due to coal settling in the pump. Even distribution of the coal throughout the loop was obtained. Plug valves were found to be the most satisfactory type especially regarding their resistance to wear, as demonstrated by BHRA tests, reported in October 1958 by D. F. Denny in a report entitled "Wear Tests on Commercial Plug Valves Handling Coal-Water Slurries".

D) Gwynnes Solids-Handling Pump

This pump was a standard gravel-pumping unit, single inlet, fully lined, with a capacity of 2,400 gal/ min at 115 ft head, 10 inch bore suction and delivery pipes. It had a scoop-controlled fluid coupling transmitting 210 HP down to 720 rpm from a slip ring 3.3 KV, 50 cycle motor. The pump for gland flushing with clean water delivered 100 gal/ min at 100 ft head. This pump was feeding directly from the mixing tank and flushing through the main pipeline. It proved capable of handling throughputs of coal in slurry of up to 270 tons/ hr, but its flat-head characteristics gave conditions conducive to pipe blockage.

Slurry Pumping Trials

These tests were later conducted in cooperation with the Central Electricity Generating Board, which was concerned with the long distance pumping of slurries from collieries to power stations. Minus 1/16 inch slurry was fed into a conical-based sump of 580 gal capacity, and was pumped by a 6 inch Vacseal slurry pump (rated at 900 gal/ min, 50 ft head), which fed into an 8 inch diameter pipe about 420 ft long. Pressures were recorded at 30 ft intervals. Valuable data were collected regarding pressure gradients and flow characteristics at low speeds and under settling conditions. It was considered that further experiments were necessary, preferably with a larger single length rather than a closed loop, to obtain more realistic assessments of size degradation. It was felt that higher concentrations than the 63% tested at Markham should also be considered. The influence of the corrosion and absence of lining of the test pipes was also questioned.

WOODEND TESTS

After a colloquium on hydraulic transport of solids in London in 1952, the Woodend colliery in Scotland was selected for underground-to-surface trials of hydraulic transport of coal. The output of the mine was 350 tons/day, including 250 tons of anthracite and 100 tons of bituminous coal. The anthracite, crushed to minus 3 inches size, was to be transported with available mine drainage water (about 750 gal/min.) In 1954 a single cylinder reciprocating feeder to introduce the coal mixture in the pipeline was designed on the basis of a suggestion by the BHRA, and built by the Cowdenbeath workshops. The pipeline included (starting from the feeder at the pit bottom) a 50 ft long leg (on a 30° slope), a vertical leg of 250 ft up the shaft, and a horizontal leg of 320 ft to the washery. In 1955 the simple open circuit system showed the feasibility of transporting coal in that manner, but caused serious pollution of a stream at the surface. The system was modified in 1956 to work on a closed circuit, with a circulating water pump on the surface and a return water pipeline leading to the feeder at the pit bottom. Endurance tests were carried out until 1957. After modifications were made both on the surface and underground, the trials were resumed in March 1959. Meanwhile, tests on alternative feeders had been conducted at Markham as reported above, and also at Central Engineering Establishment (CEE), Bretby. The original feeder at Woodend was dismantled in September 1959, and a new feeder installed late in 1959. This was a horizontal lock hopper feeder built by CEE. Trials were carried out until March 1960, when the investigations were stopped. However they had proved the technical possibility of hydraulic transport of lump coal to the surface in a continuous pipeline, and they had shown the feasibility of the horizontal lock hopper feeder at high pressures.

Simple Open Circuit

The pipe drainage water was pumped at the pit bottom by a Mather and Platt multi-stage centrifugal pump, delivering 750 gal/min through a 9 inch pipe to a hydraulic feeder, similar to the BHRA Reciprocating Feeder described above as tested at Markham. The solids pipeline was a 7 inch seamless steel pipe. Excess drainage water was pumped through the existing 14 inch main. Each feeder plunger was 6' 3" long and 9 inch diameter, with "Fescolized" surfaces for wear protection. The pockets were 7 inch in diameter. A 10 HP motor gave 120 to 140 strokes/min for a capacity of 60 tons/hr. On the surface, the coal was screened, and the dirty water after passing through hydrocyclones was discharged into silt lagoons, causing serious pollution of the nearby streams. To avoid this difficulty, a closed circuit was installed.

Simple Closed Circuit

In order to close the circuit, the clarified water recovered at the surface was pumped down the mine shaft by a Harland "Uniglide" horizontal (split-casing) centrifugal single stage pump, with a 7 inch suction and a 6 inch discharge, driven at 1470 rpm by a 120 HP motor, and capable of generating a 252 ft head with 1100 gal/ min in an 8 inch pipe leading underground to the BHRA feeder of 60 tons/ hr capacity. After numerous modifications of a mechanical nature, the revised closed circuit was completed in March 1959, but trials with the single cylinder BHRA feeder were hampered by oversize solids. However it was generally felt that this type of feeder was unsuitable for continuous operation. The suction feed was virtually ineffective, as the grid quickly became choked with solids. The maximum throughput achieved was 40 tons/ hr.

Closed circuit operation using the three cylinder horizontal lock hopper feeder

This feeder was of a type similar to the horizontal lock hopper feeder, tried at Markham and described above, but it was equipped with 3 loops for continuity of flow. The loops were arranged in a vertical bank for compactness. Each loop was 86 ft long with an 8 inch bore like the pipeline, as compared to the 6 inch diameter of the circulating water lines. The valves made by Audley Engineering Co. were of the fully-round-way type with grease-lubricated plug, cam-operated by integral pneumatic actuators. Feeder pressure was 150 psi. Feeder cycle was 39 seconds. Coal-impregnated grease caused difficulties. On the contrary, the 8 inch solids transport valves of inverted plug design were quite satisfactory. The solids feed pump was a 6 inch "Vacseal" with a capacity of 1100 gal/ min at 20 ft head, driven by a 25 HP motor.

Intensive testing of the installation was carried out from early January to the end of March 1960, when the project was discontinued, after transporting 1840 tons of coal. Leakage through the feeder was about 18 gal/ min.

Later, arrangements were made to transfer the feeder and ancillary equipment to the Central Electricity Generating Board for the installation of an experimental 6000 ft overland hydraulic transport system, feeding coal from Walton Colliery to Wakefield power station.

The Woodend tests have shown that the horizontal lock hopper feeder was the most promising of the methods considered for the feeding of lump coal into a pressurized pipeline.

TRELEWIS TESTS

This NCB project on hydraulic mining methods included the hydraulic transport of fine coal and water from the pit bottom to the surface plant. Two single-entry "Clearway" centrifugal pumps worked in series. Each pump driven by a 100 HP motor was rated at 470 gal/min for a 171 ft head. The solids pipeline was a standard 6 1/2 inch steel pipe with Victaulic joints, the pumping distance being 2,760 ft with a vertical lift of 170 ft.

BHRA STUDIES

In addition to the contributions mentioned above (mainly the BHRA reciprocating feeder), the British Hydromechanics Research Association carried out numerous experiments on a laboratory scale, such as were reported in their report RR637 "Experiments on the hydraulic transport of mixed-size solids" by S.T. Bonnington, October 1959. These studies complemented and generally confirmed the results and equations, given by R. Durand and E. Condolios in their paper entitled "Study of the transport of solids in pipes" (Société Hydrotechnique de France, June 1952, published by "Houille Blanche". Also published in Proc. Colloquium on Hydraulic Transport, by National Coal Board, Nov. 1952). It was found that the agreement was generally good between the correlation equations of Durand and Condolios, and the data reported by other research workers, such as BHRA and:

(1) Blatch, N.S. Trans. Am. Soc. Civ. Engrs., 57, pp. 400-8, (1906).
(2) Howard, G.W. " " " " " 104, 8, Part 2, pp. 1334-76, (1939).
(3) Newitt, D.M., Richardson, J.F., Abbott, M., and Turtle, R.B. "Hydraulic Conveying of Solids in Horizontal Pipes". Trans. Instn. Chem. Engrs., 33, 2, pp. 93-110, (1955).
(4) Smith, R.A. "Experiments on the Flow of Sand-water Slurries in Horizontal Pipes". Trans. Instn. Chem. Engrs., 33, 2, pp. 85-92, (1955).
(5) Workneh, H.G. "Hydraulic Transportation of Solids in a Horizontal Pipe". Thesis, Carnegie Inst. Technology (May 1956).

CENTRAL ELECTRICITY GENERATING BOARD (CEGB)

After the National Coal Board suspended all studies on the hydraulic transportation of coal in 1960, the CEGB obtained from the NCB a lot of the equipment, that had been designed and built for the NCB large scale experiments. Since 1960, the CEGB has continued the studies, especially in a research station near Brighton. In August 1962, the Brighton installations and other research facilities concerned with solids pipeline studies (including corrosion) were to be gathered together in a new location in the Southampton area:

Marchwood Engineering Laboratories,
Marchwood Power Station,
Nr. Southampton, Hampshire, G.B.

The CEGB activities were discussed with Mr. Bain, Chief Research and Development officer in London, and a visit was made at the Brighton-Hove solids pipeline research station (Mr. D.E. Elliott, Mr. Terry Sparkes, and Mr. Brian Gliddon).

It may be noted that Mr. Elliott and Mr. Sparkes had been working on the solids pipeline projects of the NCB, at Markham Colliery, until the programme was suspended. The CEGB research installations at Brighton-Hove included the following loops of pipe: 1800 feet of 10 inch pipe, 800 feet of 4 inch pipe, and 1100 feet of 6 inch pipe. The initial loop of 1800 feet of 10 inch pipe was later reduced to 1200 feet to suit more satisfactorily the available ancillary equipment (pumps, etc.)

The feeder is of the same type as the horizontal lock hopper feeder, designed by the Ministry of Power, and installed by the NCB at Markham as described above.

The installations include International Combustion Vacseal pumps, and centrifugal slurry pumps. Small blades on the impellers direct the slurry away from the most fragile parts (glands). The efficiency is low (less than 45%).

Size degradation studies have been most important recently. Typical results have shown that, in 9 hours of operation of the loops, a minus 1/2 inch coal was usually reduced in size to a minus 1/8 inch coal.

Most of the CEGB investigations have dealt with coal larger than slurry, usually minus 1/2 inch. This dimension causes difficulties when trying to keep the coal in suspension in the tanks. Improvements to the present solutions of dewatering and drying problems will be considered in the future.

A large scale project of the CEGB now very favourably considered is the transportation of minus 1/2 inch coal, in a water suspension containing 30 percent of solids, through a pipeline of 6.5 inch diameter and 9.5 miles in length, from the Forth Collieries to a power station. The pumps to be used are of the Wilson-Snyder type.

Another project involves the large scale transportation of coal from East Midlands to London in 6 or 7 years from now.

Another advanced project, which has been delayed about 9 months by difficulties to obtain the right of way, is a pipeline from Walton to Wakefield in Yorkshire. This pipeline, of 5 inch diameter and 1.5 mile length, will transport 600 tons/day of minus 1/2 inch coal from the mine to a power station. In spite of the opposition shown by the railways, it is expected that this pipeline will be established in March 1963. Preliminary tests have included studies of the rate of wear of the pipe on 400 to 500 feet of bare pipe during 14 to 15 hours per day with 900 tons/day in a flow including 45% of solids. The pumps are of the reciprocating type.

OTHER DEVELOPMENTS IN SOLIDS PIPELINING IN BRITAIN

International Combustion Products Ltd.

The International Combustion Products Limited has designed and built the IC Lock Hopper Pumping System for the conveyance of solid materials by pipelines either in mining operations or over long distances. It is suggested that the IC system may be used for pulverized coal, fly ash, limestone, clay, chemical slurries, etc. An example of such an application is the coal tailings disposal at the NCB Westfield opencast coal site. The slurry underflow (28 tons/hour) from a 75 feet Hardinge Auto-Raise Thickener is pumped over 3,600 feet through a 3 inch cast iron pipeline to a lagoon area, 80 feet higher. The lock hopper is of the vertical type, from which the slurry is expelled by high pressure clean water supplied by pumps that are not in contact with solids. In this case the clear water is conveniently supplied by the Thickener. The lock hoppers are two vessels, each of 20 cu. ft., rated at 325 psi working pressure, supplied by Stokes, Taylor and Shaw Ltd. The high pressure pumps are two 3 inch nine-stage Morrison turbine pumps (one standby), rated at 153 gpm. against 325 psi at

1460 rpm. The dirty water pumps are two 3 inch IC Vacseal pumps (one standby) in Ferloy metal, rated at 153 gpm against a 12 ft head at 720 rpm. The isolation valves are eight 3 inch cast iron Audco valves, of the rectangular port, tapered plug type, grease lubricated, and pneumatically operated. The pipeline is a 3 inch, class F, spun cast iron to B.S. 1211, supplied by Stanton Iron works. The slurry is 53% solids by weight and 40% solids by volume with an average specific gravity of 1.3. This installation is described in detail in IC publication G626.

Stewarts and Lloyds, Ltd.

As one of the largest manufacturers of steel and iron pipe in the world (42,000 employees in Britain alone), this company is very interested in any developments in pipelines, including solids pipelining. Some documentation was obtained from Mr. M.J. Conway of the London office, including a valuable report entitled "Conveyance of solids by pipeline", by Stewarts and Lloyds Ltd., Glasgow M/RD/MHS, 21st March 1962. The current research undertaken by Stewarts and Lloyds Ltd. includes investigations(usually on 2 inch pipe loops) of the flow characteristics of different materials in a test pipeline, and the selection of suitable pipe materials to meet problems of abrasion and corrosion which may arise. Besides fine pulverised coal, it is considered that irregular lump coal may be conveyed by pipeline, even with coal pieces up to one third of the pipe diameter. Following is a list of materials suggested by Stewarts and Lloyds as susceptible of liquid (usually water) pipeline conveyance: coal, gravel, granite, stone, ashes, limestone, cement, concrete, dust, clay, sand, potash, gilsonite, bauxite, slurries, chemical mixtures, wood (chips, pulp, fibres), tins, furniture parts, sewage, rubbish.

Stewarts and Lloyds, Ltd. gave the following examples of hydraulic transport of solids either existing or contemplated: in Britain, large scale coal pipelines have been tested by the NCB at Markham and Woodend collieries, and the CEGB are installing an experimental plant to pump coal from Walton colliery to Wakefield power station, as described above in this report; the Tunnel Portland Cement Co. Ltd. operates pipelines for conveying limestone in a slurry with water for cement-making; the English Clays Lovering Pochin and Co. Ltd. company pumps refined china clay slurry several miles (in the St. Austell district of Cornwall) as well as gravel and sand slurries; the CEGB have short pipelines for the disposal of fly-ash in operation, and are considering the construction of much longer lines (the experimental pilot plant is to be set up at Hams Hall, near Coleshill, Warwicks); the South of Scotland Electricity Board

have installed or are contemplating pipelines for the disposal of fly-ash from various power stations.

Outside of Britain, Stewarts and Lloyds mentioned in addition to the Cadiz-Cleveland (Ohio) coal pipeline and the Standard Oil of California-American Gilsonite pipeline in Colorado, the following installations: 1) a 38 mile overland steel pipeline of 11.8" bore from Novovolynskaya Mines to Dobrotvorski power station in the USSR, where 200 tons/ hour of minus 6 mm coal are pumped at 600 psi by a centrifugal water pump, in conjunction with a triple plunger feeder; 2) a 10 inch bore steel pipeline, carrying 100 tons/ hour of minus 40 mm coal from the coal face, over a distance of 14, 750 ft to the shaft bottom, and then 1, 000 ft to the surface of the Debiensko colliery, in Poland (using mine drainage water); 3) a 5.7 mile steel pipeline of 14.8 inch bore carrying 250 tons/ hour of minus 2.5 mm coal from a centrifugal slurry pump, at Merlebach colliery, in France; 4) a project, now adopted by the Ruhr Coal Advisory Company, the Hard Coal Mining Association and the Society for Hydraulic Transportation, to build a 40 cm pipeline, to carry 3 million tons/ year of hard coal in West Germany; 5) in Trinidad, the Rugby Portland Cement Co. Ltd. pumps a slurry containing 3/ 4 limestone and 1/ 4 clay for cement-making; 6) in Northern Ontario, the Canadian Bechtel Corporation is considering a pipeline some 100 miles long (200 miles with gathering lines) to carry wood chips in water to Marathon on the North shore of Lake Superior.

Constructors John Brown Limited (CJB)

The CJB company has been commissioned by the Central Electricity Generating Board to construct an experimental twin - 5 inch ND pipeline system for conveying coal direct to a power station from a nearby pit, a project which is to be completed early in 1963. According to Mr. A.N. Sharp of CJB, recent years have shown a marked growth of small pipelines (lesser known than the U.S., French and Russian coal pipelines), used for the transportation of mineral ores, sand, gypsum, fly-ash, slurries, and of wood pulp, etc., by pneumatic means, in some of which CJB has cooperated in design and construction. These small pipelines apparently only cover short distances.

Gwynnes Pumps Ltd.

Gwynnes centrifugal pumps suitable for pumping solids in water have been used on a number of projects of solids pipelines, as this company has considerable experience in pumping sand, gravel and other materials, in suction dredging, silt disposal ash handling, and other installations requiring the pumping of large amounts of solids in hydraulic pipelines. Some documentation was obtained from Mr. J.B. Scrivie, Director in London, including their publication No. 806 and especially their publication No. 788A, entitled "Gwynnes Centrifugal Pumps for dredging and transporting abrasive solids".

CONCLUSION

Interesting documentation on British research in solids pipelining and related subjects was obtained from a number of organizations. Some designs, like the Mono pumps for handling slurries and the pneumatic pipeline systems, such as offered by the Sheepbridge Equipment Ltd. or the Baker Perkins Ltd. companies, seem to be limited to relatively short distances and small amounts of material to be transported. However they should not be completely discarded, and in fact pneumatic pipelines are being investigated by the British Iron and Steel Research Association, the British Coal Utilization Research Association, the NCB, and the Department of Scientific and Industrial Research.

Generally speaking, most of the research work on solids pipelines in Britain has been done under the sponsorship of the NCB and the CEGB for the transportation of sized coal rather than slurries of very fine coal. It seems that the Consolidation Coal Company from the USA had required between 5 and 10% of the capital costs involved in the construction of coal pipelines, as their fees for engineering consulting services to advise the NCB or the CEGB on the basis of their experience. This apparently was considered too high. It is estimated that the NCB has spent about 150 to 200 thousand sterling pounds in 4 or 5 years on hydraulic transport and mining of coal, including about £ 50,000 for hydraulic mining research. In the last 18 months, the CEGB seems to have spent about 30 to 40 thousand sterling pounds, but it must be noted that the CEGB recovered much of the research equipment of the NCB, and is using the experience and services of some research workers formerly employed on the NCB research programme. Finally, it must be noted that wages and salaries are much lower in Britain than in Canada and many expenses may have been charged to general operation rather than research.

It appears very likely that feasibility studies on Canadian projects of solids pipelines could be done at reasonable costs by the CEGB research organization, with the cooperation of some other experienced British concerns. However, their experience covers mainly one material (sized coal). Although this knowledge would be very useful for mine pipelines such as the Coleman Collieries project, and short distance transportation of some ores and tailings, it would not be sufficient for studies of longer pipelines, which would then require that the CEGB set up a special research program using their installation for the solution of Canadian problems.

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